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THE SOVIET TYPE-2P1P MINIATURE PENTODE

A. Azat'yan

/Figures referred to are appended/

The type-2P1P miniature pentode is especially suitable as an LF power amplifier in economical radio receivers supplied by galvanic batteries. Its maximum power output at a plate voltage of 90 volts is 0.27 watts.

Construction

The seven outlet pins (nickel wire) of the 2P1P tube (Figure 1, left) are arranged around a flat glass apron 9.5 millimeters in diameter. The angular distance between adjacent pins is 45 degrees, while between the first and seventh pins it is 90 degrees.

The tube has an oxide-coated directly-heated wolfram cathode consisting of two parallel filaments. Their upper ends inside the tube are connected with an anti-dynatron electrode in the form of two U-shaped brackets made of thin sheet nickel. Each bracket has two apertures, 5.5 millimeters wide, permitting passage of the electrons from the cathode to the plate. The terminal connecting one end of the filaments and the antidynatron electrode is led out through pin 5. For structural reasons the plate is connected with two pins -- No 2 and 6. All the electrodes of the tube are attached to two stamped mica plates, the teeth of which are supported by the inner wall of the bulb. In the upper part of the bulb, a so-called "boat" is attached under the base of the exhaust tube; the getter, which maintains the high vacuum, is vaporized here.

In spite of the absence of an antidynatron grid as such, the 2P1P tube has the typical characteristic of a pentode (Figures 4 and 5). The dynatron effect appears when the voltage impressed on the plate is less than the voltage on the screen grid. In this case, the secondary electrons, dislodged from the plate, are attracted to the electrode of higher potential, whereupon the plate current drops, giving a negative resistance characteristic at low plate voltages.

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A dynatron effect on the plate can be obtained either by introducing a third grid or by utilizing the negative space charge between the screen grid and the plate. This charge decreases the electric potential of the space between the screen grid and the plate and thus functions as an anti-dynatron grid. When the magnitude of the space charge is sufficiently great, the magnitude of the above-mentioned potential may be reduced to zero, i.e., to the cathode potential. An impassable retarding field (for secondary electrons) is produced near the plate and sends the secondary electrons back to the plate.

In the so-called beam tetrodes (6P3, 30P1M, 6V6, etc.), in order to increase the space charge, the space between the screen grid and the plate is increased to approximately three to four times the distance between the cathode and the screen grid. This ratio is even greater -- about eight times -- for the 2P1P tube. Figure 2 shows the shape and arrangement of the electrodes in this tube. During operation, when the voltage on the control grid drops to zero (at this moment the plate current reaches its maximum, the voltage on the plate -- its minimum), that is, when the voltage ratio is most favorable for the appearance of the dynatron effect, there will be a greater number of electrons in the plate screen grid space and consequently, a stronger space charge due to the greater plate current and the reduced velocity of the electrons moving towards the plate. Under such conditions, the surface of the minimum potential will be located at such a distance from the cathode that it will interlock directly with the edges of the apertures in the anti-dynatron electrode. The purpose of this electrode, as in the beam-forming plates of beam tetrodes, is to make it possible to eliminate distortions in the electric field introduced by the grid wires and to concentrate the flow of electrons in those sections of the space where the electric field has the required form.

Thus, the 2P1P tube closely resembles the beam tetrode in structure. The only difference is that the stratified flow of electrons is not caused by the grid coils because the grids are wound in different directions and with different pitch. This factor has a direct influence on the relative magnitude of the screen grid current which, as in other pentodes, amounts to 18 percent of the cathode current -- appreciably more than in beam tetrodes.

Heater Supply

The normal voltage for each filament of the 2P1P pentode is 1.2 volts and the filament current is 60 milliamps. When the filaments are connected in parallel, the filament current is 120 milliamps (they may be supplied by one galvanic cell). When connected in series, the filament voltage is 2.4 volts and the filament current for the 2P1P tube, as well as for the three other tubes of the miniature battery series, is 60 milliamps. This makes it possible to connect the filaments of all the tubes in series and to supply them with a small amount of current at a higher voltage (4.8, 6, or 7.2 volts depending on the number of tubes in the receiver).

When provision is made for feeding the receiver tubes from an AC circuit (as in the "Efir-48" portable radio), it is better to connect the filaments in series because it is easier to smooth the ripples when the current is reduced.

The 2P1P tube can operate with one filament, but it will have only half as much output power.

Operating Conditions and Parameters

The extreme limits on electrode voltages and cathode current for the 2P1P tube are given below. To avoid trouble or shortening the life of the tube, these norms must not be exceeded by more than 10 percent even for a short time.

Max plate voltage	90 v
Max screen grid voltage	90 v
Max cathode current (sum of plate and grid currents)	
For two heater filaments	12 ma
For each heater filament	6 ma

The voltages on the electrodes are defined, as usual, with respect to the negative terminal of the cathode (the first pin when the filaments are connected in series, or the fifth when they are connected in parallel).

Parameters of the 2P1P Pentode and Recommended Operating Conditions in Class A_1 Amplification

Operating Conditions	I	II	III	IV	V	VI	VII
Filament voltage	2.4	1.2	1.2	1.2	1.2	1.2	1.2
Filament current (amp)	0.06	0.12	0.12	0.12	0.06	0.12	0.06
Plate voltage	90	90	90	90	90	67.5	67.5
Screen grid voltage	90	85	90	67.5	67.5	67.5	67.5
Bias voltage on control grid	-4.5	-5	-4.5	-3.5	-3.5	-3.5	-3.5
Peak AC voltage on control grid	4.5	5	4.5	3.5	3.5	3.5	3.5
Plate current (quiescent) (ma)	8.0	6.9	9.5	5.8	2.9	5.6	2.8
Screen grid current (quiescent) (ma)	1.8	1.5	2.1	1.3	0.65	1.3	0.65
Plate resistance, approximate (megohs)	0.11	0.12	0.1	0.15	0.3	0.13	0.26
Transconductance (ma/v)	2.0	1.95	2.15	1.8	0.9	1.8	0.9
Load resistance (kilohms)	10	10	10	18	36	12	24
Harmonic coefficient (%)	7	10	7	7	7	7	7
Output power (w)	0.25	0.25	0.27	0.16	0.08	0.12	0.06

As may be seen by comparing columns I and III, the plate current, the screen grid current, and the output power of the tube are less when the heater filaments are connected in series than in parallel. This is explained by the fact that one of the filaments -- the one attached to the No 7 pin which is a positive terminal is at a potential 1.2 volts higher than the second filament. As a result the control grid bias voltage with respect to this filament already amounts to 5.7, not 4.5 volts. On the other hand, both filaments operate under approximately identical conditions when connected in parallel.

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If an insignificant reduction of the output power is permissible in order to decrease the nonlinear distortion, the mean load resistance for the three first operating conditions should be 8,000-9,000 ohms.

The relation between the output power and the harmonic coefficient for the operating conditions in column III is shown in Figure 3. The load impedance is usually very dependent on the frequency. For dynamic loudspeakers it doubles at frequencies of 1,000-1,500 cycles per second, and is about five times greater than the effective resistance at the highest frequency of the reproducible band. Hence, an output transformer must be selected with a transformer ratio such that the minimum load resistance will be equal to 7,000-8,000 ohms.

The first three operating conditions are recommended for fixed installations operating on 90-volts plate voltage; under such conditions full utilization can be made of the output tube. When it is possible to limit the maximum output power to 0.12-0.16 watts to save the battery, it is advisable to decrease the plate current of the tube, not by increasing the bias voltage on the control grid but by decreasing the voltage on the screen grid. The lighter operating conditions under IV and VI apply to this case. When it is possible to reduce the maximum output power to less than 0.12 watts, only one heater filament is utilized Operating conditions V and VII are provided for such cases.

Characteristics

Figures 4 and 5 show the family of plate characteristics for the 2P1P pentode with the filaments connected in parallel and with a screen-grid voltage of 90 and 67.5 volts. Each curve corresponds to a specific value of control grid voltage.

The conditions illustrated by the curves in Figure 4 are preferable for tubes operating under full power in a fixed installation, and those in Figure 5 for tubes operating with a plate voltage of 70 in a portable installation.

The family of plate characteristics of the 2P1P tube when used as a triode are shown in Figure 6. In the triode connection with 11.6-milliamps plate current (4.5 and 90 volts on the electrodes) the following parameters apply: transconductance, 2.5 milliamps/volt; amplification factor, 7.5; plate resistance, 3,000 ohms. It is advisable to use the 2P1P as a triode when it is necessary to reduce its plate resistance considerably, for example, in utilizing this tube in the next to the last stage of amplification coupled to the final (usually push-pull stage by an interstage transformer.

With a plate voltage of 90 volts under Class A_1 amplification conditions, a bias voltage of 4.5 volts may be selected; but it is preferable to bring it up to 6 or 8 volts to obtain more reliable performance from the tube. The operational data of the 2P1P in a triode connection will not be discussed here as it can be determined readily for each concrete case by referring to the characteristics given in Figure 6. It is, however, necessary to remember that the abovementioned limits for the voltage and current hold good for a triode connection.

Filament Connections

When the filaments are connected in parallel, they are governed by identical operating conditions and it is necessary only to ensure proper filament voltage.

The life of the filament is much shorter if the heater voltage exceeds 1.35 1.4 volts. As far as underheating is concerned, a drop to 1.05 volts is expressed mainly by a drop in output power. Reducing the voltage below 1.05 volts affects the life of the filaments because it reduces their emissive power. Consequently, the heater voltage must be kept as close as possible to 1.2 volts with no greater permissible deviation than plus or minus 0.15 volts.

When the filaments are connected in series, the normal heater voltage equals 2.4 volts. It must not exceed the limits of 2.1-2.7 volts during operation. But even at a heater voltage of 2.4, although the filaments are absolutely identical, one of them will be more, the other less strongly heated, since the voltage is not evenly distributed between them. The explanation for this fact is that almost half the plate current is added to heater current. These currents in the filament connected with the negative terminal of the heater battery, coincide in direction and therefore add together, while in the filament attached to the positive terminal of the battery, they are in opposition, and thus subtract.

It is obvious from the foregoing that, in overheating, the filament connected with the negative battery terminal will be the one which is more greatly overheated, and will therefore burn out more rapidly. Similarly, in underheating, the filament connected with the positive terminal of the battery will be considerably underheated, which will impair its performance even more. To make both filaments subject to the same conditions, the overheated filament must be shunted.

In battery installations the heater filaments of the 2P1P pentode can be connected either in series or in parallel. In the latter case the 1A1P, 1B1P, and 1K1P tubes, operating in the preceding stages, will be connected in pairs and the filaments connected with the negative terminal of the battery will be shunted by a resistor to achieve proper balance in cathode current.

In a series connection of the filaments of all the receiver tubes to one circuit (supplied from a rectifier), it must be borne in mind that the cathode currents of all the tubes are superimposed on the common filament current in a rather complicated manner so that several shunts must be employed to equalize the heater filaments. The magnitude of the shunt resistances depends on the number of tubes, the order in which they are connected, the magnitude of the cathode currents and also the magnitude of the dropping resistor.

The manufacture of miniature battery tubes, especially the 2P1P output pentode, will facilitate the manufacture of radios operating with low power consumption.

/Appended figures follow/

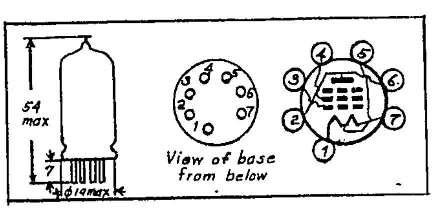

Figure 1

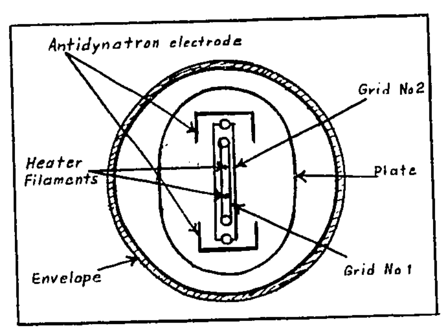

Figure 2

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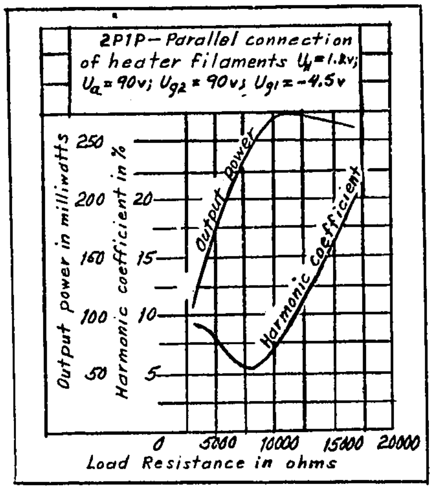

Figure 3

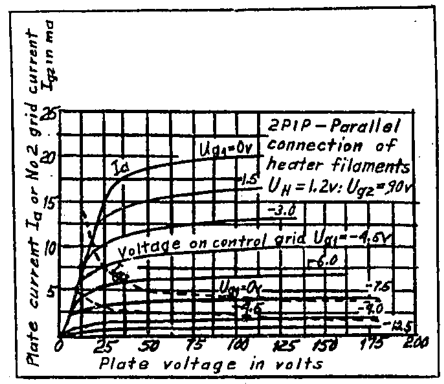

Figure 4

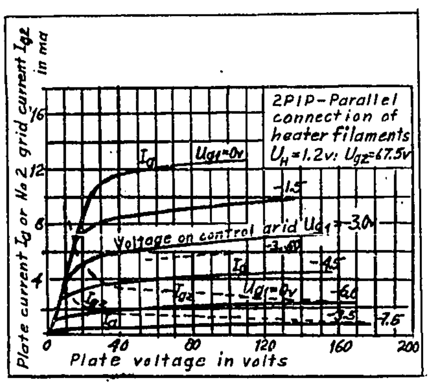

Figure 5

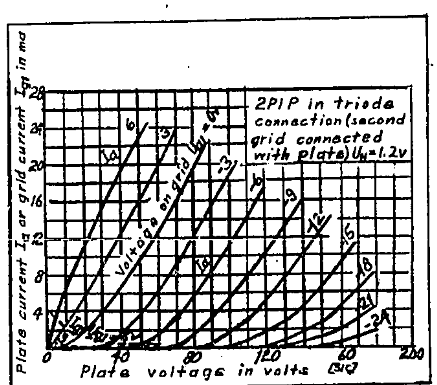

Figure 6

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